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ELEVATED-TEMPERATURE TESTS UNDER STATIC AND AERODYNAMIC CONDITIONS ON HONEYCOMB-CORE SANDWICH PANELS

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ELEVATED-TEMPERATURE TESTS UNDER STATIC AND AERODYNAMIC CONDITIONS ON HONEYCOMB-CORE SANDWICH PANELS*

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SUMMARY

Stainless-steel honeycomb-core sandwich panels which differed primarily in skin thicknesses were tested at elevated temperatures under static and aerodynamic conditions. The results of these tests were evaluated to determine the insulating effectiveness and structural integrity of the panels. The static radiant-heating tests were performed in front of a quartz-tube radiant heater at panel skin temperatures up to 1,500° F. The aerodynamic tests were made in a Mach 1.4 heated blowdown wind tunnel. The tunnel temperature was augmented by additional heat supplied by a radiant heater which raised the panel surface temperature above 800° F during air flow.

Static radiant-heating tests of 2 minutes duration showed that all the panels protected the load-carrying structure about equally well. Thin-skin panels showed an advantage for this short-time test over thick-skin panels from a standpoint of weight against insulation. Permanent inelastic strains in the form of local buckles over each cell of the honeycomb core caused an increase in surface roughness. During the aerodynamic tests all of the panels survived with little or no damage, and panel flutter did not occur.

INTRODUCTION

The design of high-speed aircraft components to withstand the effects of thermal loadings presents a serious problem, especially when conventional lightweight materials are used in the load-carrying structure. These effects can be divided into two groups: (1) those, resulting from a temperature rise, which cause alteration of the mechanical properties in the heated materials, and (2) those, due to a nonuniform temperature distribution, which cause unequal thermal expansions which, in turn, can cause thermal stresses.

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One method of coping with this problem is to protect the load-carrying structure from aerodynamic heating with a thermal insulation. Some examples of this type of construction are discussed in reference 1 which shows that for short-term high-speed flight, insulation alone can furnish adequate protection. For flights of longer duration, wherein an internal cooling system is employed, insulation serves to reduce the cooling capacity required.

The results of tests on corrugated-stiffened Inconel X panels at elevated temperatures under static and aerodynamic conditions are presented in reference 2. These results show that both panel deformation and flutter can be alleviated by proper edge support.

The purpose of the present investigation is to report the results of tests on honeycomb-core sandwich insulating panels at elevated temperatures. The sandwich panels were made of stainless steel and were composed of two thin skins separated by a lightweight honeycomb core. Individual panels differed from each other primarily in skin thickness. The investigation consisted of static radiant-heating tests and of tests under aerodynamic conditions. The static radiant-heating tests were made in order to evaluate panel insulating effectiveness and deflection and deformation characteristics. The aerodynamic tests were made at a Mach number of 1.4 in order to observe the structural integrity of the panels. The static radiant-heating tests were made in the Langley Structures Research Division, and the aerodynamic tests were performed at the NASA Wallops Station.

A short discussion of these same tests, without data, is given in reference 3; however, a more complete description of the panels and a discussion of test results are given herein.

A theoretical study of the transfer of heat through sandwich-type panels is presented in reference 4, with comparisons drawn between analytical and experimental results. The experimental data used in reference 4 to corroborate the theoretical study were obtained from tests similar to the ones described herein.

PANEL ASSEMBLIES AND TEST EQUIPMENT

Panel Assemblies

Ten panel assemblies were used in the investigation. Each assembly consisted of two identical honeycomb-core sandwich panels, a backplate, an air gap, retainer straps, and a filler block. The panel assemblies differed primarily in inner and outer skin thicknesses and are referred to hereinafter by an alphabetical notation, A, B, C, or D. (See fig. 1.)

Of the ten panel assemblies used, five (two A, one B, one C, and one D) were tested by static radiant heating and five (two A, two B, and one C) were tested in a heated blowdown wind tunnel.

Honeycomb-core sandwich panels.- The sandwich panels consisted of two thin metal skins separated by a lightweight honeycomb core. The skins, made of 17-7 PH stainless steel, were approximately 6 inches wide by 12 inches long and were of various thicknesses depending on the panel design. The skins were brazed to the honeycomb core with a 0.0025-inch-thick silver-manganese foil. The core was formed into 0.25-inch-wide hexagonal cells from 17-7 PH stainless-steel ribbons 0.3 inch wide by 0.0015 inch thick. Detail 1, in figure 1, shows an oblique cross-sectional view of a portion of a typical panel.

Backplate and air gap.- Each panel assembly consisted of two identical sandwich panels (an upper panel and a lower panel) placed one above the other in front of a backplate. Panels A, B, and C utilized a 0.125-inch-thick 7075-T6 aluminum-alloy backplate. Panel D used a 0.25-inch-thick mild steel backplate. The backplate simulated a load-carrying structure. In order to provide an air gap behind the panels, 0.081-inch-diameter steel drill rods were placed between the backplate and the sandwich panels. The air gap gave some additional insulating capacity to that already afforded by the sandwich panels, and the cylindrical drill rods allowed the panels to expand in chordwise and spanwise directions with little frictional resistance during heating by reducing the area of metal-to-metal contact.

Retainer straps and filler blocks.- Retainer straps covered a 0.25-inch-wide strip around the periphery of each panel and were held in place by bolts which extended through the thickness of the panel assembly into tapped holes in the backplate. The panel assemblies, composed of two identical sandwich panels, an air gap, a backplate, and retainer straps, were placed in a test fixture used for previous tests of slightly larger panels. Thus, a filler block was used to take up the unused space in the fixture.

Test Fixture

A test fixture was designed to fit the settling chamber of the preflight jet of the NASA Wallops Station. This fixture consisted of a Mach 1.4, 12- by 12-inch nozzle block and an attached structural steel framework. During the static radiant-heating tests the nozzle was used merely to hold the structural steel framework, while during the aerodynamic tests the nozzle formed an integral part of the tunnel. The framework, attached to the nozzle block in such a way that it would be equally adaptable for both the static and aerodynamic tests, held a panel assembly, a movable radiant heater, and reflectors in position at the nozzle exit. (See figs. 2(a) and 2(b).) A wedge-shaped leading edge on the framework (fig. 2(c)) was designed to scoop off a 0.125-inch-thick boundary layer ahead of the panel assembly. The panel assembly, in turn, was located 0.125 inch from the nozzle wall into the airstream. A quartz-tube radiant heater was mounted on the framework outside the airstream and opposite and parallel to the panel assembly. The heater could be moved, to vary the panel-to-heater distance and likewise the heating rate, by actuation of an hydraulically operated cylinder. The radiant-heating apparatus and the heating rates, (based on static radiant-heating test calibrations without accounting for the cooling effect of tunnel air flow) are discussed in the appendix. Reflector plates were attached at the top and bottom of the nozzle to contain the radiant energy between the heater and panel.

Instrumentation

The instrumentation used during the investigation consisted of thermocouples, deflectometers, and high-speed motion-picture cameras.

Thermocouples.- Each test-panel assembly was instrumented with 28 thermocouples of No. 30 chromel-alumel wire, located as shown in figure 3. Thermocouples were attached to the inner and outer skins of the panels by spotwelding; however, for the aluminum backplate the thermocouples were peened into small drilled holes.

Deflectometers.- During three of the static radiant-heating tests and all of the wind-tunnel tests, two deflectometers per panel were used to measure out-of-plane panel deflections. A deflectometer consisted of a spring-steel cantilever beam, to which was fastened a push rod which, in turn, passed through a hole in the backplate and rested against the inner skin. Deflectometers, when used, were attached near the centers of the upper and lower panels. (See fig. 3.)

Cameras.- During the aerodynamic tests, a visual record of panel behavior was recorded by 16-millimeter motion-picture cameras operating at speeds of 80 or 1,000 pictures per second. The motion-picture cameras were located to one side of the nozzle center line and were directed upstream at an angle of approximately 45° from the panel assembly. The sandwich panels were also photographed after most of the static radiant-heating tests.

Accuracy

Given in the following table are the estimated probable errors in the individual measurements and the corresponding time constants. The time constant, which is considered independent of the probable error, is defined as the time at which the recorded value of a step function input is 63 percent of the input; at three time constants, the response amounts to 95 percent of the input. Errors due to thermocouple installation have not been included; however, they are believed to be approximately ±2 percent according to the results presented in reference 2.

Measurement of -	Probable error	Time constant, sec
Stagnation pressure	±0.4 psi	0.03
Stagnation temperature	$\pm 4^{\circ}$ F	0.12
Panel temperature	$\pm 6^{\circ}$ F	0.03
Panel deflection	±0.006 in.	0.02

TEST PROCEDURE

Eleven tests were performed on ten panel assemblies at elevated temperatures (one of the A panels was tested twice, tests 6 and 7.) Five of the eleven tests were made with static radiant heating to determine panel insulating effectiveness and deflection and deformation characteristics, and the remaining six tests were made under aerodynamic conditions to determine the structural integrity of the panels under the influence of thermal loadings in aerodynamic flow.

Static Radiant-Heating Tests

Static radiant-heating tests 1, 2, and 3 on panel assemblies A, B, and C, respectively, were made by subjecting each panel to a comparable heating cycle. The heating cycle consisted of an initial interval, wherein the temperature of the outer skin of the sandwich panel was raised from room temperature at 20° F per second until $1,500^{\circ}$ F was reached, followed by a second interval of 45 seconds, wherein the temperature of $1,500^{\circ}$ F was maintained.

Since the panels A, B, and C differed in skin thicknesses, each was subjected to different applied heating rates in order to maintain the prescribed outer-skin temperature history. This temperature history was accomplished by monitoring the output of outer-skin thermocouple number 3 and by varying the voltage to the quartz-tube radiant heater to maintain the desired temperature history.

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Additional static radiant-heating tests 4 and 5 on panel assemblies A and D were performed by raising the temperature of the outer skin 20° F per second until 1,350° F was reached. This temperature level was then maintained until the backplate reached a temperature of 600° F.

Wind-Tunnel Tests

Six tests were made, primarily to determine panel structural integrity and also to observe panel deflection and deformation characteristics under the influence of thermal loading in a supersonic airstream. The tests were made in the preflight jet of the NASA Wallops Station which was used as a Mach 1.4 blowdown wind tunnel. The tunnel was operated by opening a pressure control valve which allowed dry air to escape from two storage spheres and pass through a heat accumulator before entering a Mach 1.4, 12- by 12-inch nozzle. The panels were tested in a free stream at the nozzle exit.

The panels were programmed to be tested at a temperature level as near as possible to 1,500° F, in a tunnel which had a stagnation temperature of only 680° F; therefore, in order to raise the panel skin surface temperature, the same radiant heater used during the static tests was mounted parallel to and facing the test specimens from outside the airstream. During all tunnel testing, the heater voltage was held constant at 440 volts to provide maximum heat output. In some of the tests the heater was turned on after the flow of air started from the nozzle; in other tests the heater was turned on first, so that the outer skin of the sandwich panel was hottest just before the air flow began.

Tunnel conditions for each test are shown in table I. The values given for stagnation pressure were averaged from measurements taken at selected points over the cross section of the airstream. The stagnation temperature was corrected for the position of the test panels in the airstream according to the results of profile surveys made on the nozzle used in these tests. Values obtained in this way are approximate but provide a reasonable estimate of the true stagnation temperature. Other tunnel conditions were computed from the stagnation temperature and stagnation pressure. Also included in table I are the times at which the heater was turned on during each test. Zero time is taken as the instant air began to flow from the nozzle, and all data are referenced to this time.

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RESULTS AND DISCUSSION OF THE STATIC RADIANT-HEATING TESTS

Panel Heat Transfer

Temperatures at 10-second intervals for each recorded thermocouple are given in table II, and plots of temperature histories showing outer-skin temperatures, inner-skin temperatures, and backplate temperatures for static radiant-heating tests 1, 2, and 3 are shown in figure 4. The plotted temperatures were obtained for each time interval by averaging, separately, readings of the outer-skin thermocouples, the inner-skin thermocouples, and the backplate thermocouples except those which were suspected of being seriously affected by heat sinks. For example, for tests 1, 2, and 3, the readings of inner-skin thermocouples 9, 10, 17, 18, 19, and 20 (located under a retainer strap) were discarded before averaging.

Figure 4 shows that the outer skins of panels A, B, and C experienced similar prescribed temperature rise rates. Each panel, however, did not experience the same heat input into the interior; that is, the heat transfer from the outer skin through the core to the inner skin and finally to the backplate was, in each case, different. This variation in heat input is caused by the different inner-skin thicknesses used in each panel. Comparison of all the plotted temperature histories in figure 4 indicates that for such short tests, the panel with the greater heat capacity (panel C) is the better insulator, as would be expected; however, it is to be noted that panel C is approximately four times as heavy as panel A and two times as heavy as panel B. For short-term insulating protection such as considered by these tests, the panels of lighter gauge are more efficient from a standpoint of weight against insulation.

Further study of the temperature histories in figure 4 shows that the largest temperature difference existed between the outer skin and the inner skin of panel C. This temperature difference through the panel thickness can cause thermal stresses and deformations. An example of panel deformation due to a temperature difference between outer and inner skins is discussed later.

It is evident from table II that a large amount of scatter is present in the data, especially in those temperatures recorded by outer- and inner-skin thermocouples. This scatter is primarily attributed to electrical unbalance among the three phases supplying current to the radiant heater and, in part, to the presence of heat sinks caused by retainer straps and filler blocks. Typical chordwise and spanwise plots of temperature variations across the skins of the panel assemblies are shown in figure 5; the effects of the retainer straps and end connections are evident. The temperatures at the edges of the outer and inner skins of the sandwich panels in some cases were 200° to 400° F lower than at the centers of the panels. In the backplate, temperature differences were much smaller, with the highest level usually recorded in that portion nearest the filler block. This result appeared near the end of the first 60 seconds of heating. Apparently, during this initial time, the filler block became heated sufficiently to transfer heat into the unprotected part of the back plate immediately beneath it. After 60 seconds, heat from this portion of the backplate was conducted laterally until the location of thermocouple number 24 was reached. (See fig. 3.) The temperature difference between thermocouples 23 and 24 was not large enough to affect thermocouple 23 appreciably during short-term tests of 120 seconds duration.

A theoretical study of the transfer of heat through sandwich panels is reported in reference 4 which shows that heat is transmitted from the outer skin of sandwich panels to the inner skin by conduction through the honeycomb core, by radiation from the outer skin and the walls of the honeycomb core, and perhaps to a limited extent by convection. In the theory presented in reference 4 account is also taken of two of these methods of heat transfer, conduction and radiation, and the fact that convection may be neglected without introducing an appreciable error is shown. Also, in reference 4, conduction is shown to be the dominant factor in the heat transfer through these sandwich panels, and, if radiation between the skins of the sandwich panels and to the backplate is taken into account, the theory is in agreement with the results of similar tests on a panel identical to panel A of the present study. (See fig. 6.)

The results of extended time tests 4 and 5 on panels A and D are shown in figure 7. Plots of the temperature histories of the outer skins, inner skins, and backplates were obtained by averaging, separately, readings of all outer-skin thermocouples, all inner-skin thermocouples, and all backplate thermocouples. The temperature histories show that the temperature rise in the load-carrying structure is about inversely proportional to its heat capacity.

Panel Deformation

Deflectometer data are given in table III, and plots of out-of-plane panel deflections during tests 1, 2, and 3 on panels A, B, and C, respectively, are shown in figure 8. During the time interval between 0 and 60 seconds, all panels experienced an outer-skin temperature rise of approximately 20° F per second. Thus, the outer skin of each panel would, theoretically, expand by the same amount. This correlation of expansion would not be the case for the inner skins since each panel utilized different inner-skin thicknesses and, hence, experienced a different inner-skin temperature rise rate.

During the static radiant-heating tests on panels A, B, and C, skin surface deformations appeared at temperatures in excess of 900° F. These deformations are attributed to thermal stresses in the heated outer skins of the panels. These stresses, in turn, gave rise to permanent inelastic strains in the form of local buckles over each cell of the honeycomb core. Measurements of the buckle depths were made at random over the outer skins of panels A, B, and C after completion of all the static radiant-heating tests. These measurements were then averaged for each panel. The depths of the buckles and the maximum front surface temperatures experienced during testing are shown in the following table:

Panel	Depth of buckle, in.	Maximum temperature, °F
A	0.013	1,500
B	.002	1,500
C	.002	1,450

An empirical relationship between deflection and temperature difference through the panel thickness for tests 1, 2, and 3 was formulated in the same manner as was done in reference 2. A straight line was faired through a plot of panel deflections against average temperature differences through the panel thickness. This line determined that for panel A the deflection was equal to 0.000169 times the temperature difference through the panel thickness. For panels B and C the constants of proportionality were, respectively, 0.000175 and 0.000131. A comparison of the empirical relationship to the experimental data up to a time of 50 seconds is shown in figure 8. At about this time panel buckling took place.

RESULTS AND DISCUSSION OF THE WIND-TUNNEL TESTS

Panel Heat Transfer

Temperatures recorded by each thermocouple are shown in table II. The wide range in the temperatures recorded by the skin thermocouples may be caused, in part, by variation of the heat-transfer coefficient along the chordwise axis of the panel and by the possibility of separated flow (the retainer straps protruded 0.0625 inch above the outer skin into the air flow). However, as was noted during the static radiant-heating tests, this temperature variation is also attributed to the fact that many of the thermocouples were located near heat sinks caused by retainer

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straps. Thermocouples 7 and 8 are considered as nonrepresentative for the aerodynamic tests since they gave widely divergent readings for no apparent reason when compared with thermocouples 1, 2, 3, and 4. Figure 9 shows typical plots of temperature against time. These plots were obtained by averaging temperatures from centrally located thermocouples 2 and 3 for the outer skin, thermocouples 12 and 13 for the inner skin, and thermocouples 22 and 23 for the backplate. Comparison of the backplate temperature histories of figure 9 with those of figure 4 shows that the backplate heated more rapidly in the wind-tunnel tests than in the radiant-heating tests, even though the outer- and inner-skin temperatures were lower. This result was probably due to convective heating caused by flow of the tunnel air to points adjacent to the backplate; therefore it may be inferred that these aerodynamic tests were not suitable for measuring the insulating characteristics of the panels. However, if such panels are used to insulate an aircraft structure, care must be taken to insure that heated air from the boundary layer does not flow in around the edge connections and heat the load-carrying structure by direct convection.

Panel Deformation

Structural integrity.- The results of the tests showed that the panels were structurally adequate for the test conditions imposed; that is, the panels remained intact in the test fixture throughout the tests but experienced some local buckling. Panel flutter or vibration is not discernible in the high-speed motion-picture film records.

Deflections.- Deflections recorded by each deflectometer are given in table III. As the temperature difference between the outer skin and inner skin increased, the panel deflected (bowed) toward the airstream. Later, when the temperature difference decreased, the deflection toward the airstream diminished and reversed its direction. By the time the inner-skin temperature reached about half the magnitude of the outer-skin temperature, the panel had returned to its original position, after which it deflected away from the heater and the airstream.

Creases.- One panel assembly (panel A, test 10) sustained an irregular transverse crease across both the inner and outer skins of the upper section of one honeycomb-core sandwich panel and also diagonal corner creases on the outer skin of the lower section. (See fig. 10.) This panel, one of the lightest of those tested, was subjected to the most severe outer-skin temperature rise rate imposed on any panel. Analysis of the high-speed motion pictures showed that the transverse crease was first noticeable at -2 seconds (minus sign indicates time prior to air flow), and at -1 second the crease became pronounced. Average temperature differences through the thickness of the panel at these times were about 300° F and 800° F, respectively, while the maximum temperature differences in the

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plane of the outer skin of the panel were 70° F and 195° F. The temperature variation through the panel was much higher in this tunnel test than in any of the radiant-heating tests, but this was not the case for temperature differences in the plane of the outer skin. From these considerations, it seems probable that the creases resulted mainly from a temperature difference through the panel thickness.

CONCLUDING REMARKS

Stainless-steel sandwich panels were tested at elevated temperatures in front of a quartz-tube radiant heater at panel skin temperatures up to 1,500° F and in a Mach 1.4 blowdown wind tunnel at skin temperatures above 800° F. The tests were performed to determine panel insulating effectiveness and structural integrity under the effects of heating, both with and without air flow.

For short-term (2-minute) tests, all of the sandwich panels insulated a load-carrying structure about equally, and the thin-skin panels showed an advantage from a standpoint of weight against insulation. The heat transfer through these panels appears to be predominantly caused by conduction, and, if radiation between the skins of the sandwich panels and to the backplate is taken into account, temperatures can be predicted according to a theory presented in NACA TN 4349.

During the static radiant-heating tests, sandwich-panel skin deformations due to thermal stresses in the outer skin which gave rise to permanent inelastic strains over each cell of the honeycomb core were large enough to cause an increase in roughness of the panel surface. In one case this roughness amounted to 0.013 inch.

All of the panels tested under aerodynamic conditions deflected into the airstream until the maximum temperature difference between the inner skin and the outer skin was reached. After this time the deflection reversed direction, and the panel passed through the original position and deflected away from the heater and the airstream.

All of the panels tested at elevated temperatures in the Mach 1.4 wind tunnel survived the tests with little or no damage. Panel flutter did not occur.

One of the lightest gauge panels tested sustained an irregular transverse crease across its inner and outer skins during radiant heating just prior to a tunnel blowdown. This crease resulted from thermal stresses induced by a temperature difference of approximately 300° F between the inner and outer skins.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Field, Va., April 6, 1959.

APPENDIX

RADIANT-HEATING APPARATUS

The radiant-heating apparatus used in these tests was developed for the purpose of simulating aerodynamic heating in aircraft structures. The heater shown in figure 2(b) was made of 180 lamps arranged in four quadrants of 45 lamps each. One quadrant was subdivided into 3 bays of 15 lamps each. Each bay could be energized separately for photographic purposes. The lamps consisted of a straight filament sealed in a 3/8-inch-diameter quartz tube of 10-inch lighted length. These lamps were spaced in two staggered banks at 0.5-inch centers and were held in place by slotted side plates which served as mechanical supports and as terminals through which the electrical current passed. The side plates were bolted to a fixture which also served as the specimen holder. (See fig. 2.) The distance between the heater and the front surface of the specimen was adjustable in a range between 12 and 24 inches. Reflectors were provided at the top and bottom only, since the fixture was adapted to fit the nozzle exit of a blowdown wind tunnel.

Power was drawn from a 400-kilowatt source and connected in delta to the lamps with 60 lamps per phase. At 440 volts, each lamp drew approximately 3 kilowatts and 6.7 amperes. Heating rates achieved are shown in figure 11.

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TABLE I.- TEST CONDITIONS

(a) Static radiant-heating tests

Test	Panel assembly	Heating rate	Purpose
1	A	Outer-skin temperature rise rate, 20° F/sec to 1,500° F, and 1,500° F for 45 additional seconds.	Measurement of temperatures and deflections.
2	B	Outer-skin temperature rise rate, 20° F/sec to 1,500° F, and 1,500° F for 45 additional seconds.	Measurement of temperatures and deflections.
3	C	Outer-skin temperature rise rate, 20° F/sec to 1,500° F, and 1,500° F for 45 additional seconds.	Measurement of temperatures and deflections.
4	A	20° F/sec to 1,350° F, and 1,350° F until backplate reaches 600° F.	Measurement of temperatures.
5	D	20° F/sec to 1,350° F, and 1,350° F until backplate reaches 600° F.	Measurement of temperatures.

(b) Wind-tunnel tests

Test	Panel assembly	Mach number	Stagnation pressure, lb/sq in. abs	Stagnation temperature, °F	Free-stream pressure, lb/sq in. abs	Free-stream dynamic pressure, lb/sq in. abs	Free-stream temperature, °F	Free-stream velocity, ft/sec	Free-stream density, slugs/cu ft	Speed of sound, ft/sec	Reynolds number, per ft × 10^{-6}	Additional radiant heating[a]	
												On, sec	Off, sec
6	A	1.42	51.9	675	15.8	22.4	349	1,979	0.00164	1,394	5.00	None	None
7	A	1.42	50.0	663	15.3	21.6	340	1,969	.00160	1,386	4.88	2.4	22.2
8	B	1.42	50.3	620	15.4	21.7	310	1,931	.00167	1,360	5.13	2.2	22.0
9	C	1.42	50.3	637	15.4	21.7	322	1,947	.00165	1,371	5.04	-2.6	17.2
10	A	1.42	50.5	639	15.4	21.8	323	1,947	.00165	1,371	5.06	-2.7	17.1
11	B	1.42	49.3	533	15.1	21.2	248	1,851	.00179	1,304	5.55	-4.8	15.0

[a]Minus (-) sign indicates time prior to air flow.

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TABLE II.- TEMPERATURE DATA

(a) Static radiant-heating tests

Test	Panel assembly	Time, sec[a]	Temperature at thermocouple, °F: 1	2	3[b]	4	5	6	7	8	9	10	11	12	13
1	A	0	83	83		83	83	83	83	83	83	83	83	83	83
		10	240	275		260	187	220	275	106	114	111	110	122	123
		20	388	469		416	291	345	465	297	166	166	175	234	229
		30	518	654		554	391	465	648	481	233	234	258	381	374
		40	686	859		721	517	614	854	685	318	324	354	558	542
		50	851	1,069		904	665	782	1,063	892	425	431	471	752	729
		60	1,046	1,284		1,090	836	964	1,281	1,110	566	562	603	949	926
		70	1,246	1,481		1,291	1,036	1,166	1,488	1,304	744	724	723	1,126	1,099
		80	1,302	1,506		1,334	1,140	1,247	1,529	1,341	907	880	799	1,213	1,187
		90	1,313	1,510		1,358	1,208	1,304	1,544	1,353	1,032	1,000	839	1,225	1,204
		100	1,311	1,507		1,363	1,251	1,336	1,539	1,352	1,123	1,091	864	1,231	1,211
		110	1,329	1,509		1,379	1,288	1,369	1,538	1,349	1,195	1,159	892	1,236	1,217
		120	1,336	1,512		1,393	1,317	1,400	1,542	1,355	1,252	1,218	919	1,239	1,224
2	B	0	79	79		79	79	79	79	79	79	79	79	79	79
		10	247	280		228	251	241	274	275	115	127	105	114	101
		20	401	479		369	411	401	474	478	199	199	156	197	179
		30	538	673		497	554	554	664	671	288	293	236	325	299
		40	705	890		652	723	736	884	889	423	411	336	486	451
		50	887	1,101		831	914	942	1,098	1,103	567	549	449	668	626
		60	1,036	1,270		979	1,064	1,104	1,262	1,267	719	704	579	851	812
		70	1,219	1,487		1,181	1,264	1,322	1,472	1,475	911	891	713	1,036	1,004
		80	1,258	1,505		1,224	1,312	1,371	1,496	1,497	998	1,043	827	1,166	1,141
		90	1,268	1,502		1,237	1,336	1,393	1,491	1,494	966	1,149	887	1,221	1,199
		100	1,289	1,512		1,271	1,374	1,432	1,510	1,509	978	1,221	918	1,243	1,227
		110	1,288	1,500		1,266	1,374	1,429	1,490	1,486	1,001	1,274	942	1,254	1,337
		120	1,245	1,440		1,226	1,332	1,384	1,431	1,430	1,023	1,308	955	1,256	1,240
3	C	0	79	79		79	79	79	79	79	79	79	79	79	79
		10	225	279		286	247	244	271	276	140	130	82	82	82
		20	380	513		494	411	424	493	497	240	227	95	102	103
		30	510	708		668	558	588	685	688	349	332	114	146	145
		40	718	979		934	792	835	955	965	500	475	144	204	203
		50	1,004	1,314		1,265	1,073	1,135	1,286	1,299	746	702	193	299	293
		60	1,076	1,492		1,368	1,179	1,268	1,431	1,444	962	920	262	434	428
		70	1,107	1,504		1,280	1,224	1,312	1,442	1,453	1,084	1,042	329	572	565
		80	1,097	1,452		1,327	1,214	1,294	1,387	1,396	1,160	1,122	390	678	674
		90	1,091	1,451		1,338	1,240	1,317	1,394	1,400	1,210	1,175	438	759	758
		100	1,087	1,439		1,328	1,248	1,320	1,382	1,389	1,245	1,216	482	826	822
		110	1,083	1,439		1,325	1,256	1,331	1,380	1,383	1,270	1,243	575	876	873
		120	1,090	1,447		1,324	1,264	1,340	1,383	1,388	1,293	1,271	542	920	917

Test	Panel assembly	Time, sec[a]	Temperature at thermocouple, °F: 14	15	16	17	18	19	20	21	22[c]	23	24	25	26	27	28
1	A	0	83	83	83	83	83	83	83	83		83	83	83	83	83	83
		10	112	120	118	105	108	105	107	81		82	84	82	82	82	83
		20	177	222	221	145	156	155	150	84		84	85	84	84	85	84
		30	260	359	357	197	222	219	206	86		88	89	88	88	89	88
		40	358	515	518	260	303	305	274	90		96	98	96	96	98	94
		50	475	694	702	340	401	412	361	96		107	111	107	107	112	105
		60	606	882	896	441	517	551	476	106		126	136	122	124	132	123
		70	752	1,069	1,083	569	666	723	616	121		155	175	149	149	161	149
		80	856	1,191	1,204	698	811	890	749	141		191	227	185	184	199	183
		90	913	1,235	1,242	808	929	1,018	860	162		227	269	230	224	233	219
		100	951	1,249	1,254	901	1,019	1,115	949	182		258	314	274	264	264	250
		110	978	1,255	1,258	973	1,089	1,191	1,019	202		287	363	318	303	293	280
		120	1,004	1,262	1,266	1,031	1,147	1,255	1,079	222		315	410	363	340	319	307
2	B	0	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79
		10	94	103	103	109	124	127	122	79	78	77	78	79	78	78	78
		20	139	175	175	155	195	200	184	78	78	79	82	80	79	79	79
		30	208	287	289	219	282	293	262	83	82	82	89	84	81	81	81
		40	298	432	438	303	389	414	360	88	88	87	101	90	87	87	87
		50	399	604	619	407	496	564	479	95	97	96	117	100	96	95	96
		60	500	787	805	518	640	729	607	105	112	113	142	116	109	109	109
		70	610	970	993	659	825	933	768	120	135	136	176	139	131	128	131
		80	705	1,108	1,139	771	979	1,089	888	140	164	167	215	179	162	154	159
		90	758	1,174	1,204	856	1,091	1,193	968	163	198	200	256	231	200	185	192
		100	792	1,202	1,234	917	1,173	1,272	1,038	184	229	233	295	278	239	217	224
		110	815	1,213	1,243	982	1,288	1,322	1,084	207	260	263	332	327	276	245	255
		120	838	1,217	1,247	989	1,282	1,348	1,113	228	287	291	366	369	311	273	284
3	C	0	79	79	79	79	79	79	79	79	79	79	79	79	79	79	79
		10	86	81	80	110	127	129	126	80	79	80	79	79	78	77	78
		20	105	103	102	168	216	216	213	80	79	79	82	78	79	78	78
		30	141	145	145	241	321	327	316	84	81	80	88	81	80	79	78
		40	190	204	207	340	472	484	458	88	83	83	99	84	84	83	82
		50	267	297	298	498	716	741	686	95	87	87	115	90	90	87	86
		60	376	427	432	643	937	973	892	103	93	94	140	101	101	95	93
		70	475	555	558	740	1,067	1,105	1,006	117	103	107	173	114	117	108	105
		80	553	657	661	802	1,141	1,177	1,067	132	120	125	209	132	135	124	121
		90	613	735	740	845	1,189	1,226	1,105	149	139	147	244	152	157	144	140
		100	659	803	804	874	1,229	1,261	1,128	168	162	170	276	175	182	168	163
		110	696	852	856	895	1,352	1,287	1,149	186	186	195	305	201	208	191	187
		120	729	895	897	914	1,277	1,310	1,167	204	211	222	333	227	236	217	210

[a]Temperatures given for time 0 seconds are room temperatures.
[b]Thermocouple 3 used for control in tests 1 to 3.
[c]Thermocouple 22, test 1, was inoperative.

TABLE II.- TEMPERATURE DATA - Continued

(a) Static radiant-heating tests - Concluded

Test	Panel assembly	Time, sec[a]	Temperature at thermocouple, °F												
			3	4	5	6	7	8	13	14	15	16	23[b]	27	28
4	A	0	77	77	77	77	77	77	77	77	77	77	77	77	77
		25	537	366	463	455	514	891	231	128	246	242	82	82	79
		50	974	693	863	869	972	986	576	253	614	601	112	109	107
		75	1,331	1,005	1,169	1,218	1,329	1,345	936	415	996	982	165	163	163
		100	1,331	1,049	1,256	1,255	1,351	1,352	1,017	473	1,091	1,075	237	232	233
		125	1,338	1,064	1,293	1,277	1,351	1,352	1,039	510	1,099	1,097	295	289	292
		150	1,338	1,079	1,300	1,291	1,351	1,352	1,053	525	1,106	1,104	335	333	336
		175	1,331	1,086	1,307	1,298	1,344	1,352	1,061	539	1,113	1,118	377	372	376
		200	1,338	1,101	1,321	1,313	1,358	1,352	1,075	554	1,128	1,132	410	409	410
		225	1,331	1,116	1,315	1,313	1,344	1,352	1,075	561	1,128	1,132	440	436	440
		250	1,338	1,123	1,321	1,313	1,344	1,345	1,090	583	1,128	1,132	470	466	472
		275	1,338	1,131	1,329	1,320	1,351	1,352	1,097	598	1,143	1,140	497	493	497
		300	1,338	1,139	1,329	1,320	1,351	1,352	1,105	598	1,150	1,147	522	520	522
		325	1,338	1,139	1,321	1,320	1,344	1,352	1,105	605	1,150	1,147	545	542	544
		350	1,338	1,145	1,329	1,313	1,336	1,345	1,105	613	1,150	1,147	565	562	566
5	D	0	77	77	77	77	77	77	77	77	77	77	77	77	77
		40	869	508	731	620	756	755	451	262	443	471	82	82	85
		80	1,432	1,080	1,243	1,163	1,321	1,321	1,011	608	1,026	1,082	118	110	116
		120	1,431	1,125	1,295	1,245	1,336	1,344	1,048	682	1,081	1,124	169	160	165
		160	1,424	1,139	1,325	1,275	1,328	1,329	1,048	712	1,081	1,124	218	208	212
		200	1,424	1,162	1,333	1,290	1,336	1,329	1,048	749	1,088	1,132	259	253	256
		240	1,424	1,169	1,333	1,290	1,321	1,321	1,063	763	1,096	1,132	300	291	300
		280	1,424	1,177	1,333	1,290	1,321	1,321	1,056	778	1,088	1,132	338	331	333
		320	1,416	1,184	1,333	1,297	1,321	1,321	1,063	800	1,096	1,139	374	362	370
		360	1,431	1,192	1,333	1,297	1,321	1,329	1,071	808	1,096	1,146	405	397	401
		400	1,416	1,192	1,333	1,290	1,305	1,299	1,071	815	1,088	1,132	433	425	429
		440	1,424	1,199	1,325	1,290	1,305	1,306	1,078	822	1,096	1,139	466	455	458
		480	1,416	1,199	1,325	1,290	1,313	1,306	1,078	830	1,112	1,146	492	478	484
		520	1,431	1,206	1,333	1,305	1,321	1,321	1,093	837	1,112	1,153	517	503	510
		560	1,424	1,199	1,325	1,297	1,298	1,306	1,093	859	1,112	1,153	540	523	528
		600	1,431	1,214	1,333	1,305	1,321	1,314	1,108	867	1,120	1,161	561	543	548
		640	1,416	1,206	1,325	1,297	1,305	1,306	1,093	874	1,120	1,153	579	561	567
		680	1,416	1,214	1,333	1,297	1,298	1,299	1,100	889	1,112	1,153	597	581	582

[a]Temperatures given for time 0 seconds are room temperatures.
[b]Thermocouple 23 used for control.

[redacted]

TABLE II.- TEMPERATURE DATA - Continued

(b) Wind-tunnel tests[a]

Test	Panel assembly	Time, sec	Temperature at thermocouple, °F																											
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
6	A	0	144	122	118	107	106	106	91	100	90	88	100	94		84	85	84	95	91	90	87	91	88	86	82	86	86	83	83
		3	369	421	409	445	323	366	192	305	178	160	133	150		125	156	130	193	176	172	198	98	80	96	88	96	94	98	96
		6	393	434	424	458	346	380	194	316	248	218	184	198		190	210	190	282	250	245	280	117	82	110	96	112	110	116	114
		9	414	449	441	473	361	396	198	326	291	266	226	231		246	234	224	328	297	292	332	138	126	123	108	126	124	131	130
		12	426	452	447	480	374	406	198	328	322	302	260	254		282	246	242	360	330	325	360	160	140	138	121	146	140	142	140
		15	438	458	454	487	386	410	201	330	346	327	285	270		308	258	258	378	352	348	380	179	152	148	132	159	153	154	150
		18	444	464	459	494	389	414	201	334	358	346	304	282		331	267	269	386	368	364	396	197	163	156	144	172	166	163	160
		21	448	466	463	495	396	426	202	335	372	360	318	290		348	276	278	396	381	378	408	210	171	168	157	182	178	173	172
		24	455	469	466	498	399	429	205	338	383	371	332	296		358	281	284	404	390	387	413	223	180	176	168	196	189	184	182
		27	458	470	466	499	403	430	199	331	388	380	344	301		368	288	292	408	394	394	417	236	189	184	178	208	198	192	190
7	A	0	153		122	110	107	96	92	106	96	90	112	104	93	89	92	89	98	94	95	90	102		92	84	91	92	90	91
		3	491		548	598	438	512	242	406	180	162	141	156	136	126	156	133	197	188	186	209	108		100	88	100	102	102	100
		6	633		834	912	652	792	314	599	333	256	230	241	244	278	256	224	342	350	378	431	127		116	102	116	117	117	116
		9	681		878	962	706	837	327	628	458	368	309	322	348	414	318	314	464	472	519	586	151		128	119	134	134	132	130
		12	714		896	984	745	861	332	641	548	453	364	372	417	512	362	375	524	564	618	674	177		141	138	153	152	147	146
		15	732		914	1,006	772	884	336	652	618	526	401	398	458	576	391	416	555	624	690	728	196		160	158	171	166	158	158
		18	744		923	1,016	794	898	336	654	668	592	430	424	492	622	414	446	573	682	750	772	217		164	182	194	186	165	163
		21	756		933	1,024	812	909	342	668	709	642	454	438	510	651	444	476	583	720	787	793	232		175	230	208	204	176	180
		24	535		576	641	548	544	228	415	704	690	450	434	506	654	445	475	546	694	750	728	249		186	289	222	218	188	190
		27	498		492	540	478	445	202	352	617	613	414	383	434	578	400	415	482	620	656	622	260		193	288	243	233	196	200
8	B	0	120	107	99	94	100	104	88	94	90	89	96	92	88	84	86	85	93	92	88	88	89	89	90	82	84	83	88	84
		3	445	486	478	512	438	419	204	340	180	151	115	110	116	89	126	104	186	186	182	202	92	96	96	81	96	94	100	94
		6	601	782	767	854	686	649	282	525	344	267	165	174	173	134	192	159	340	362	364	411	103	112	105	85	112	109	116	108
		9	644	866	850	946	743	712	298	566	458	358	210	242	244	210	240	210	428	484	490	548	115	126	121	97	130	128	125	120
		12	662	882	867	972	760	723	302	574	542	429	250	305	301	282	268	256	490	569	574	627	130	142	136	110	150	146	138	130
		15	674	896	876	977	768	734	310	580	596	484	280	354	346	341	292	290	525	624	633	672	145	154	150	126	164	162	150	144
		18	686	904	884	989	782	748	309	581	641	524	302	416	403	386	307	317	552	666	678	704	160	172	163	142	180	180	164	157
		21	697	912	894	990	790	761	311	583	672	554	324	457	440	424	320	337	574	696	708	727	172	184	176	158	194	196	178	171
		24	524	660	644	704	558	540	242	424	648	562	333	475	452	448	326	349	552	658	670	661	183	193	188	174	208	211	188	180
		27	470	516	498	538	452	446	208	341	566	529	330	432	402	444	306	338	490	586	594	574	194	196	188	190	218	221	198	192
		30	446	471	460	490	427	412	192	308	520	504	324	410	382	434	294	330	453	535	546	532	202	200	192	203	224	225	198	193

[a]Blanks in data indicate thermocouple malfunction.

[redacted]

[redacted]

TABLE II.- TEMPERATURE DATA - Concluded

(b) Wind-tunnel tests[a] - Concluded

Test	Panel assembly	Time, sec	Temperature at thermocouple, °F																											
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
9	C	-3	108	96	92	86	86	88	82	84	86	85	103	94	90	84	86	83	92	84	84	83	95	88	90	84	84	87	86	84
		0	710	778	759	636	770	750	318	522	168	166	106	96	88	84	82	81	208	221	220	228	96	89	85	82	86	88	80	82
		3	651	854	836	730	782	760	322	591	325	314	126	126	121	124	108	110	364	394	396	444	100	100	97	92	100	100	92	88
		6	653	845	826	779	792	780	323	587	436	429	144	156	156	162	146	144	456	524	524	570	110	112	110	106	118	117	112	109
		9	668	853	834	803	814	792	320	591	518	520	162	184	190	198	172	168	510	610	616	646	116	122	120	120	135	133	124	123
		12	684	864	848	820	826	800	319	593	572	588	184	208	217	241	196	192	538	672	680	688	125	133	127	137	152	145	138	135
		15	696	874	863	828	832	814	320	602	617	639	202	232	241	281	218	217	555	710	728	711	136	144	137	156	166	164	148	147
		18	598	754	746	723	700	686	284	527	656	690	222	252	264	317	240	238	549	720	736	707	147	152	151	177	182	182	161	159
		21	463	510	502	536	472	459	202	344	616	632	236	264	272	324	249	248	476	631	646	597	160	164	153	186	199	198	170	168
		24	439	462	455	483	428	424	192	309	555	566	247	267	276	325	259	254	437	560	572	530	170	174	163	194	208	207	181	178
10	A	-3	111	97	89	88	87	79			88	84	101	93	90	81	81	83	90	84	84	78	90	88	87	76	82	84	84	81
		0	956	1,218	1,226	1,049	1,327	1,061			280	150	136	146	133	107	137	144	159	206	212	206	89	85	81	71	84	86	85	78
		3	634	864	798	890	824	746			408	326	231	306	312	245	300	320	246	376	388	436	98	98	94	78	95	100	103	97
		6	653	856	790	869	808	748			504	448	270	361	364	322	349	367	366	504	517	561	118	115	111	88	119	120	122	115
		9	673	872	802	882	822	758			571	534	309	392	393	373	375	393	412	586	606	630	138	128	118	97	138	137	137	127
		12	692	886	824	892	840	778			615	590	336	410	416	423	390	412	438	644	669	668	156	141	134	120	158	160	147	140
		15	706	890	831	910	844	802			651	635	360	428	434	464	490	426	461	690	714	693	173	154	156	143	178	180	159	153
		18	549	662	612	712	592	604			648	654	380	432	440	482	422	435	466	697	723	680	189	166	160	156	194	196	173	167
		21	462	484	468	516	436	437			555	566	346	386	398	426	373	381	424	607	628	570	202	178	172	168	206	212	181	176
		24	430	453	441	480	413	413			509	516	332	348	369	385	348	354	394	544	560	514	213	184	184	191	220	224	195	187
11	B	-6	114	107	106	95	98	96	80	88	92	86	110	102	102	90	87	86	94	91	88	85	97	91	97	90	90	90	90	88
		-3	499	532	550	516	546	518	215	376	154	110	111	106	106	90	86	86	142	148	165	159	97	91	93	88	91	92	84	84
		0	970	1,093	1,112	976	1,062	1,036	400	757	335	242	174	178	166	144	150	167	258	281	330	321	97	90	93	88	90	94	88	86
		3	642	953	958	918	868	879	342	670	426	392	255	288	290	236	250	260	358	416	472	482	102	104	106	96	109	106	103	96
		6	630	893	896	889	820	837	318	624	480	487	288	338	354	298	282	326	414	524	567	562	114	118	117	108	134	120	114	110
		9	640	878	884	884	820	835	314	613	526	556	310	368	392	327	304	374	455	622	632	610	124	128	128	124	163	137	128	122
		12	652	876	885	898	834	841	316	616	571	611	338	380	418	358	324	410	486	660	674	644	138	142	142	143	177	154	140	137
		15	664	882	886	900	842	852	314	618	606	649	356	398	432	384	328	424	508	690	705	665	152	153	150	158	193	166	152	149
		18	441	520	518	559	486	500	204	374	336	622	355	389	429	390	336	430	458	609	626	566	161	160	162	176	214	184	163	163
		21	410	430	424	473	415	422	178	308	328	543	342	352	392	375	311	400	414	532	546	494	172	170	172	188	216	192	172	172

[a]Blanks in data indicate thermocouple malfunction.

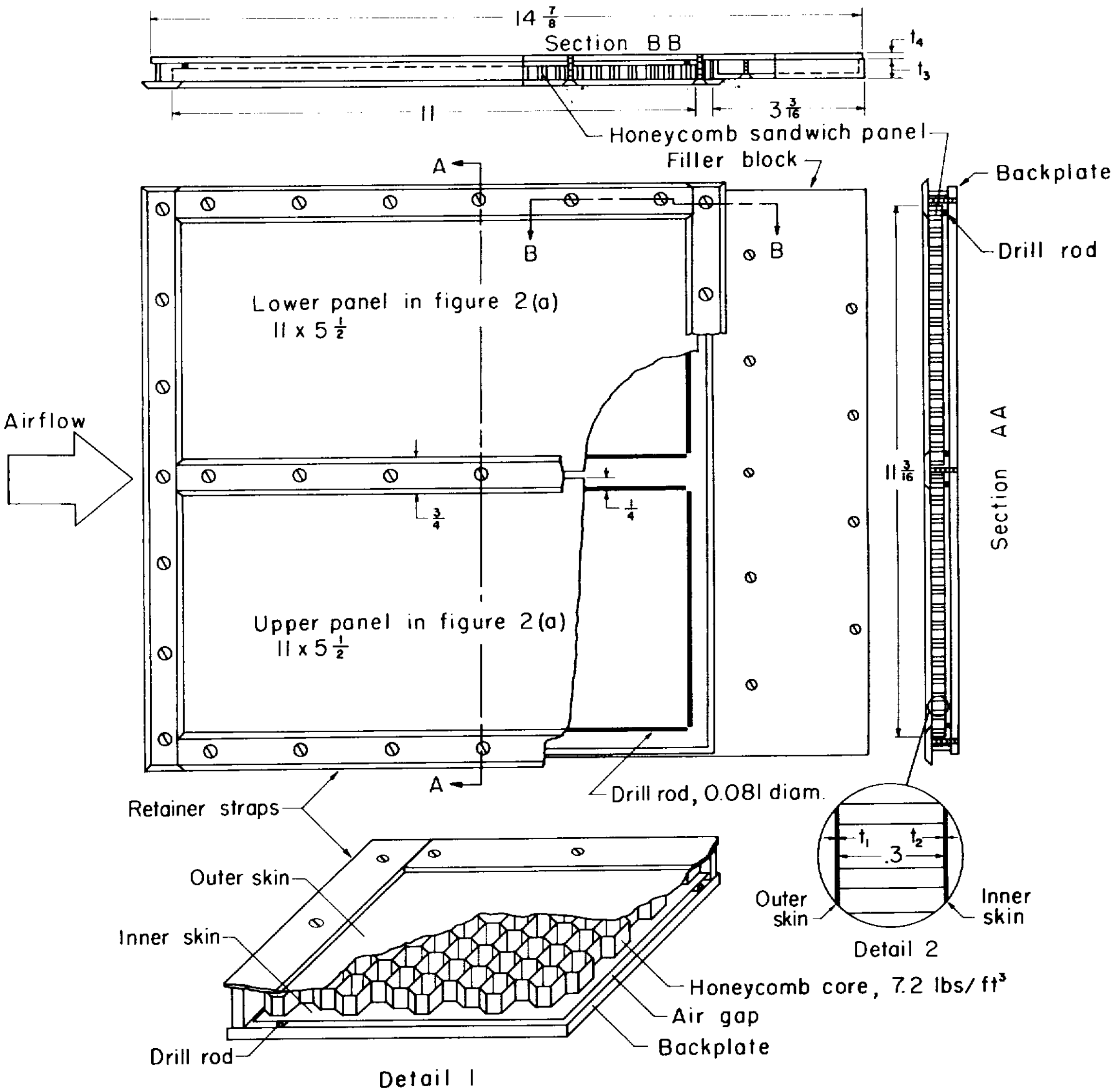
[redacted]

TABLE III.- DEFLECTION DATA[a]

Deflection, in.																					
Test	1		2		3			6		7		8		9		10		11	
Panel assembly	A		B		C			A		A		B		C		A		B	
Time, sec	Upper panel	Lower panel	Upper panel	Lower panel	Upper panel	Lower panel	Time, sec	Upper panel	Lower panel	Upper panel	Lower panel	Upper panel	Lower panel	Upper panel	Lower panel	Upper panel	Lower panel	Upper panel	Lower panel
0	0.000	0.000	0.000	0.000	0.000	0.000	-6											0.000	0.000
10	.018	.019	.025	.023	.017	.023	-3							0.000	0.000	0.000	0.000	.055	.058
20	.029	.021	.046	.043	.044	.050	0	0.000	0.000	0.000	0.000	0.000	0.000	.093	.088	.078	.087	.122	.127
30	.034	.037	.060	.058	.065	.072	3	.025	.025	.039	.041	.041	.038	.094	.088	.027	.032	.073	.079
40	.039	.043	.072	.070	.095	.102	6	.014	.016	.051	.055	.068	.062	.084	.079	.011	.017	.048	.056
50	.041	.043	.076	.073	.105	.110	9	.008	.010	.040	.042	.064	.061	.077	.072	.005	.009	.040	.050
60	.035	.033	.067	.066	.076	.078	12	.001	.006	.034	.034	.056	.050	.072	.067	-.001	.003	.033	.045
70	.024	.016	.063	.062	.064	.067	15	-.003	.001	.028	.025	.048	.044	.068	.062	-.005	.001	.028	.039
80	.019	.008	.048	.048	.045	.048	18	-.007	-.002	.021	.021	.040	.035	.044	.037	-.036	-.026	-.030	-.008
90	.020	.009	.041	.042	.039	.042	21	-.007	-.002	.019	.016	.035	.030	.005	.002	-.055	-.040	-.042	-.012
100	.022	.011	.041	.040	.031	.034	24	-.009	-.004	-.024	-.029	-.005	-.006	-.004	-.007	-.049	-.042		
110	.025	.014	.037	.036	.026	.029	27	-.011	-.006	-.030	-.033	-.023	-.021						
120	.028	.018	.025	.024	.024	.025	30					-.027	-.024						

[a]Minus (-) indicates deflection away from heater.

[redacted]

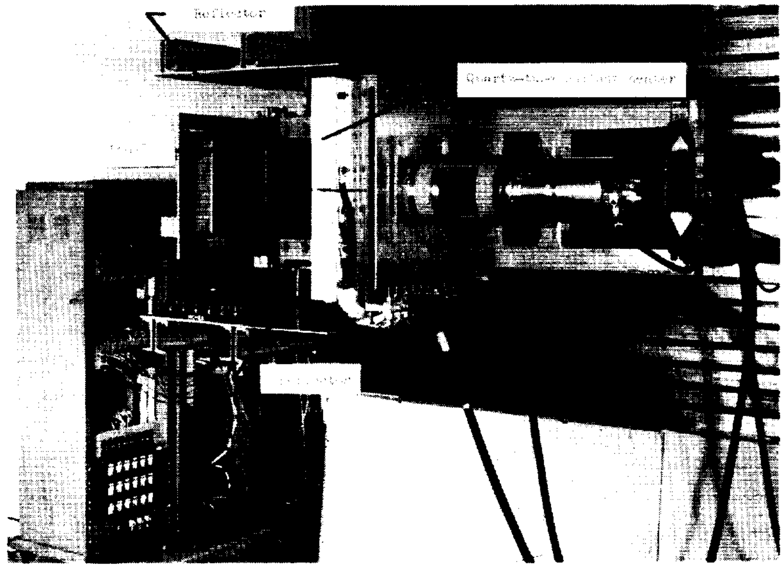


Dimension	Panel			
	A	B	C	D
t_1	.005	.010	.010	.005
t_2	.005	.010	.005	.005
t_3	.395	.410	.440	.395
t_4	.125	.125	.125	.250

Figure 1.- Typical panel assembly. Linear dimensions are in inches.

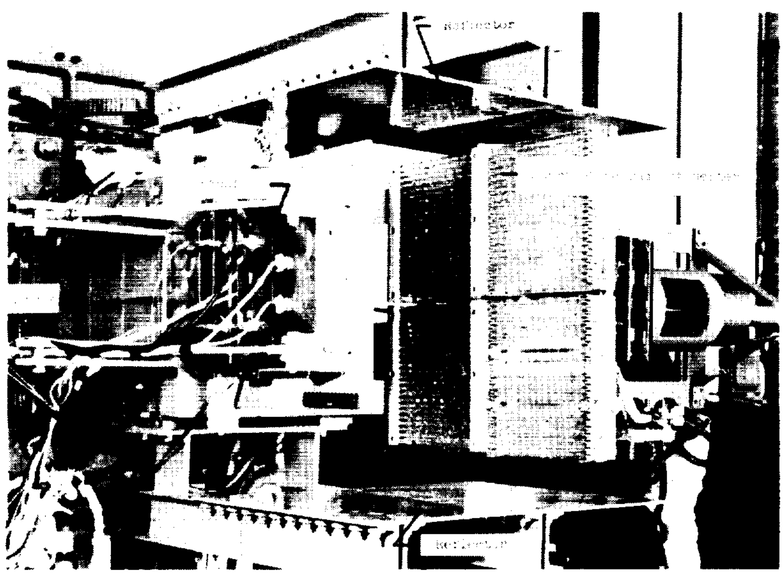
[redacted]

[redacted]



L-94081.1

(a) Right-hand view of test fixture mounted on wall in Langley Structures Research Division.

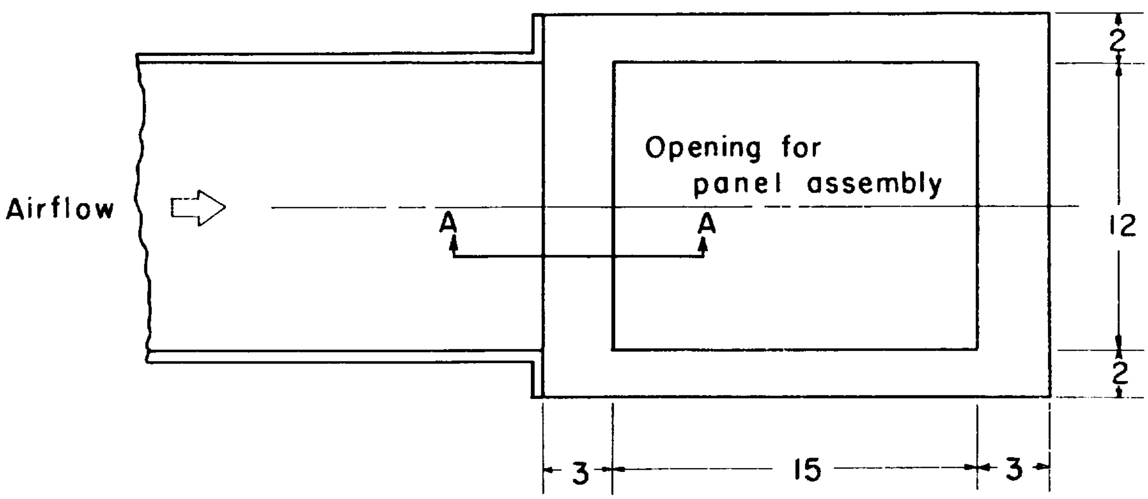


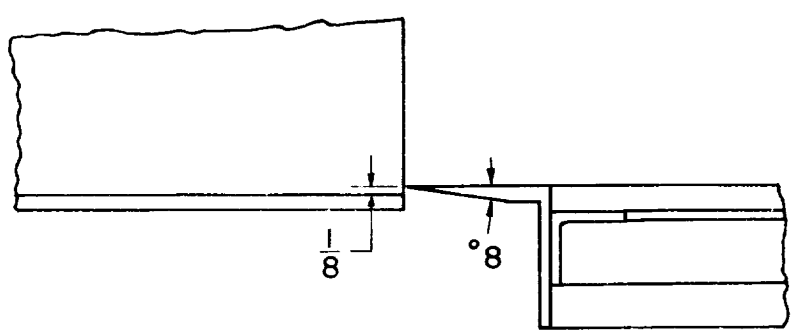
L-94967.1

(b) Left-hand view of test fixture mounted at exit of a Mach 1.4 blowdown wind-tunnel nozzle at NASA Wallops Station.

Figure 2.- Test fixture.

[redacted]





Section AA

(c) Sketch of wedge-shaped leading edge and location of panel at nozzle exit.

Figure 2.- Concluded.

[redacted]

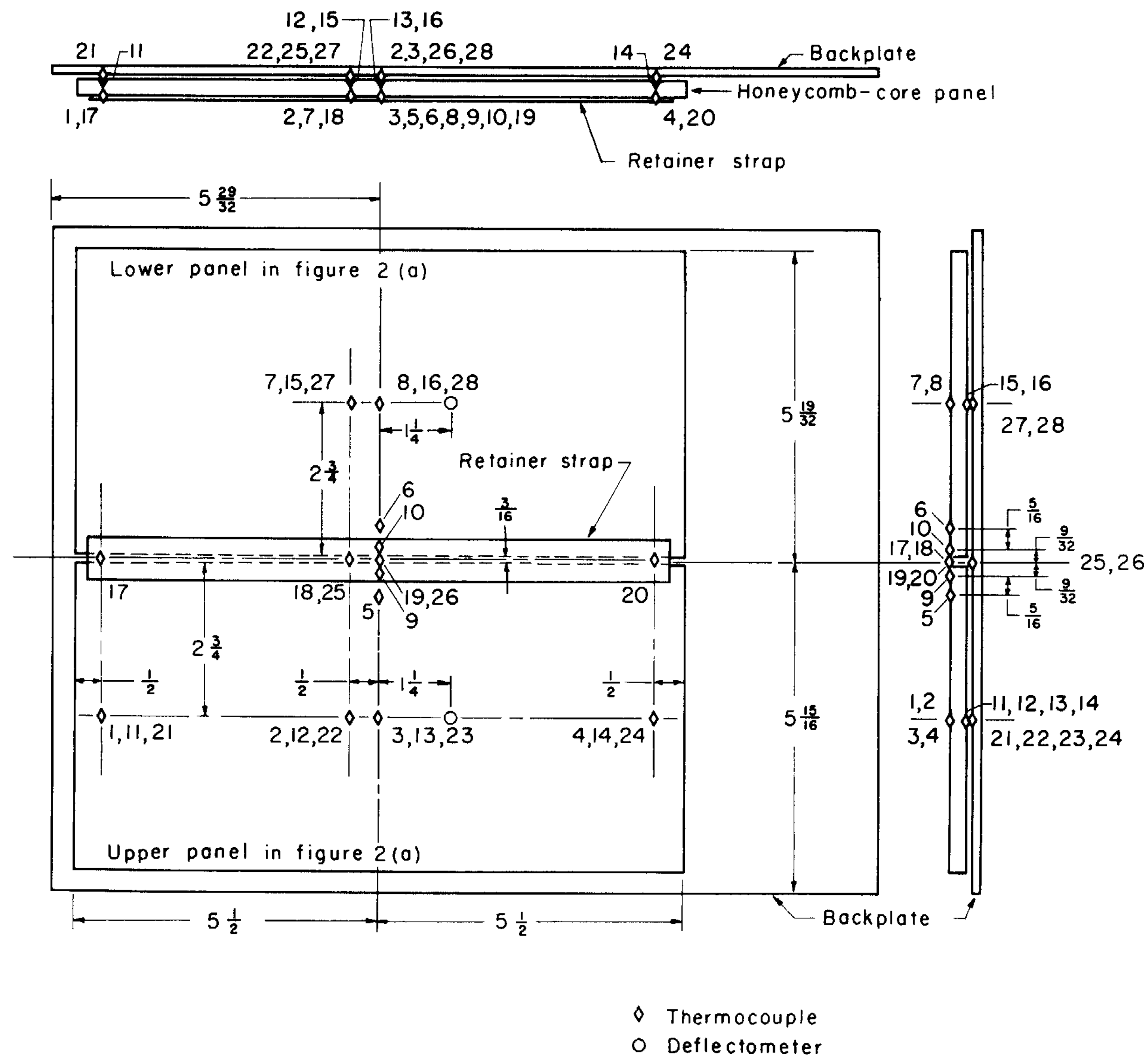
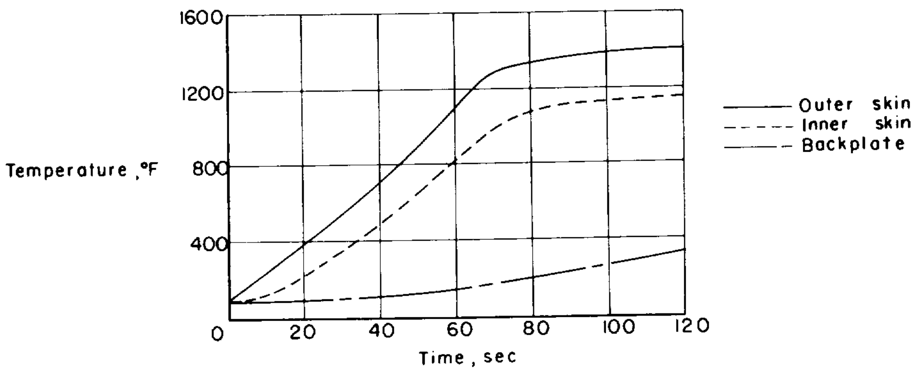
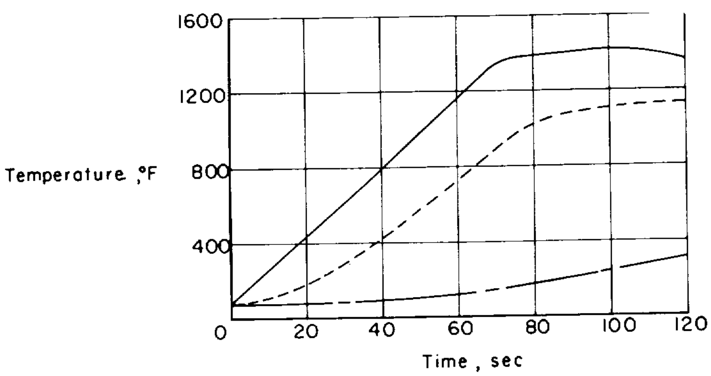


Figure 3.- Typical thermocouple locations. Panel assembly is shown with peripheral retainer straps and filler block removed. Linear dimensions are in inches.

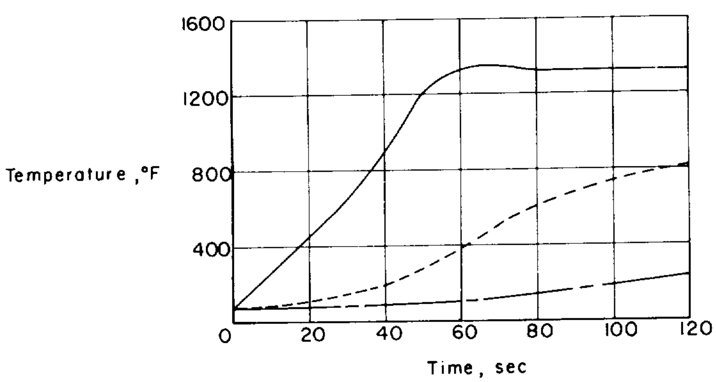
[redacted]



(a) Temperature history for panel A, test 1.



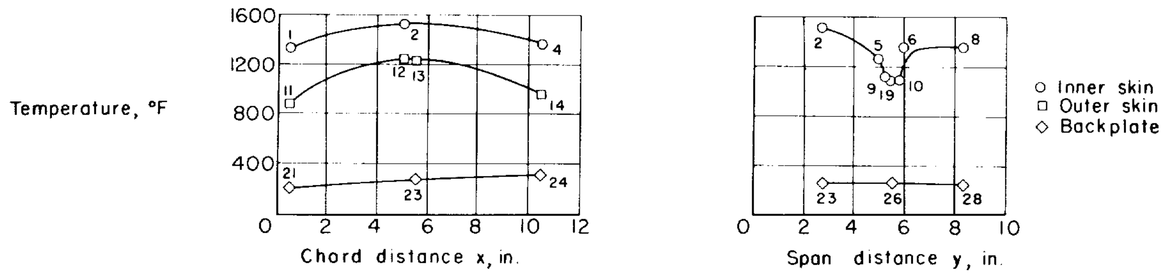
(b) Temperature history for panel B, test 2.



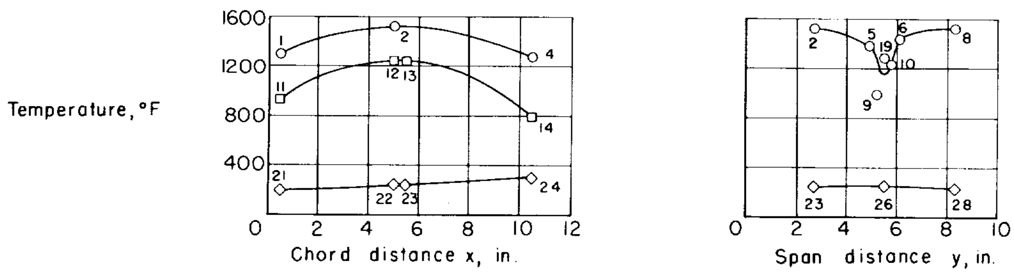
(c) Temperature history for panel C, test 3.

Figure 4.- Typical temperature histories for static radiant-heating tests.

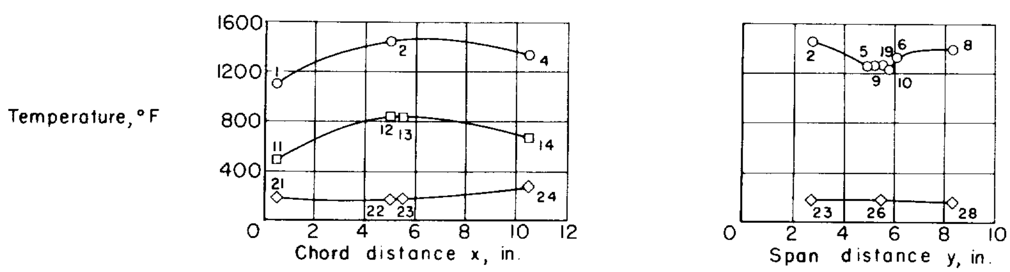
[redacted]



(a) Typical chordwise and spanwise plots of temperature variations for panel A, test 1.



(b) Typical chordwise and spanwise plots of temperature variations for panel B, test 2.



(c) Typical chordwise and spanwise plots of temperature variations for panel C, test 3.

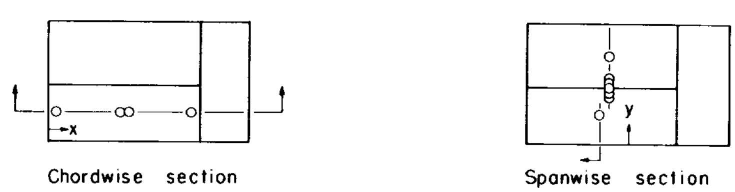


Figure 5.- Typical chordwise and spanwise plots of temperature variation for static radiant-heating tests 1, 2, and 3. Values shown were taken at 100 seconds. Chordwise distances are measured from leading edge of panel and spanwise distances are measured from side of lower panel.

[redacted]

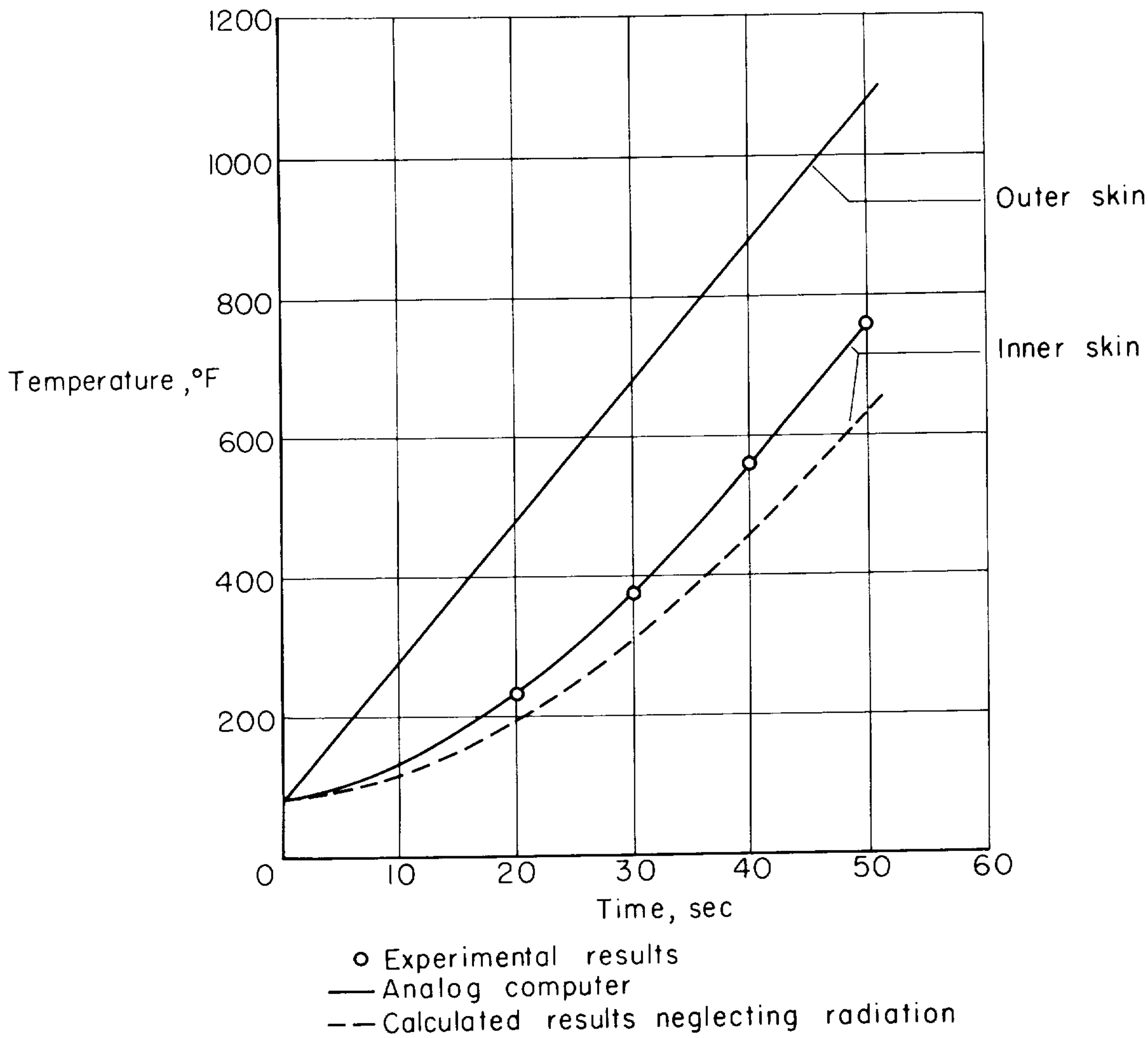
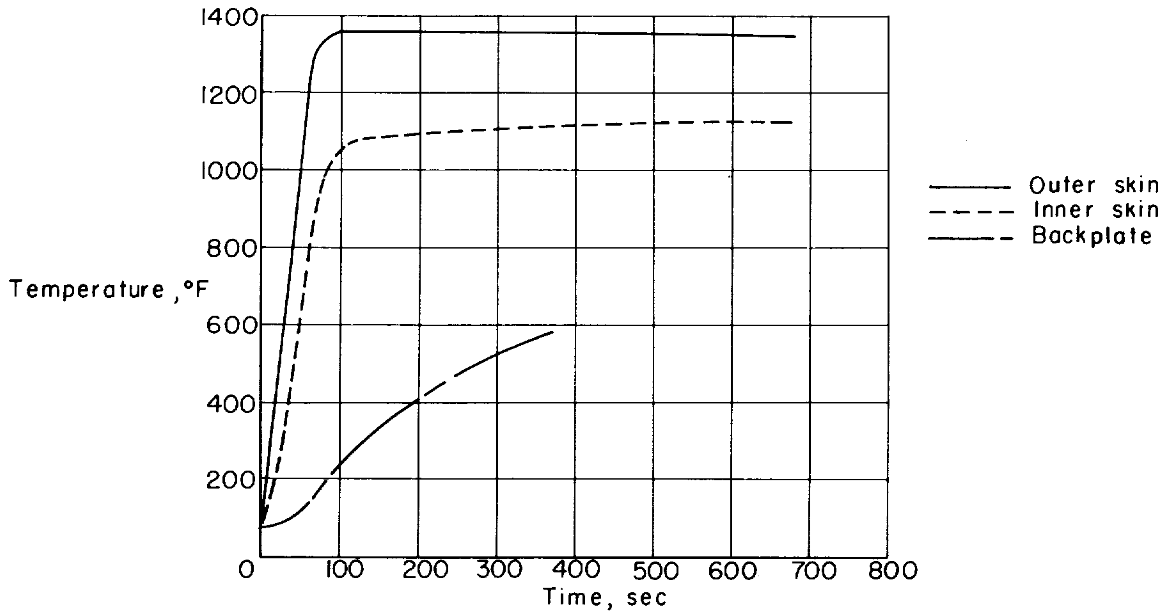
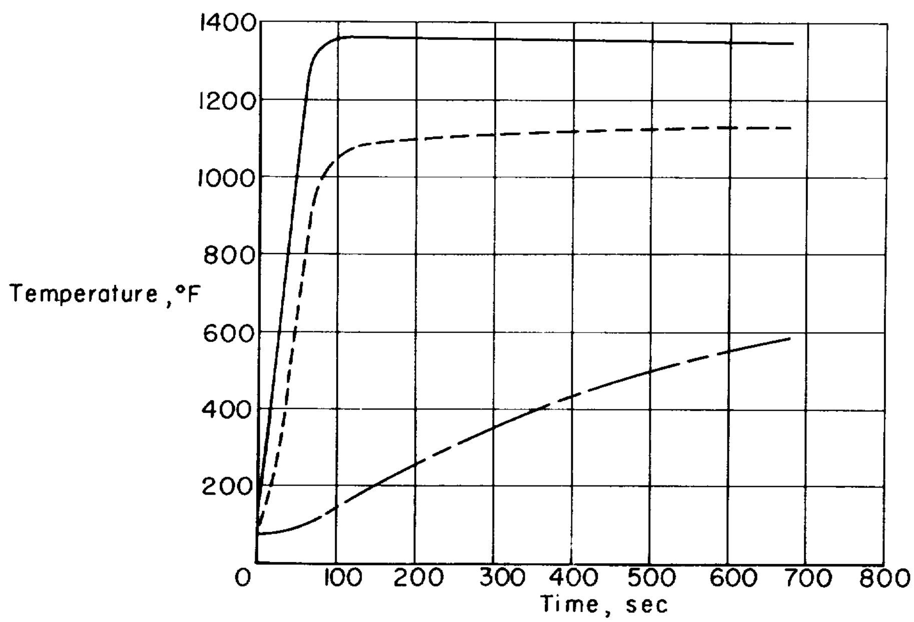


Figure 6.- Comparison of experimental and calculated results for a typical honeycomb-core sandwich panel. (From NACA TN 4349.)

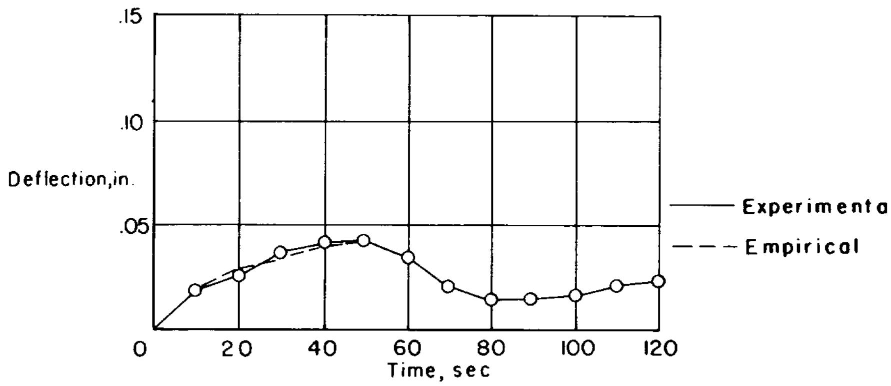


(a) Temperature history for panel A, test 4.

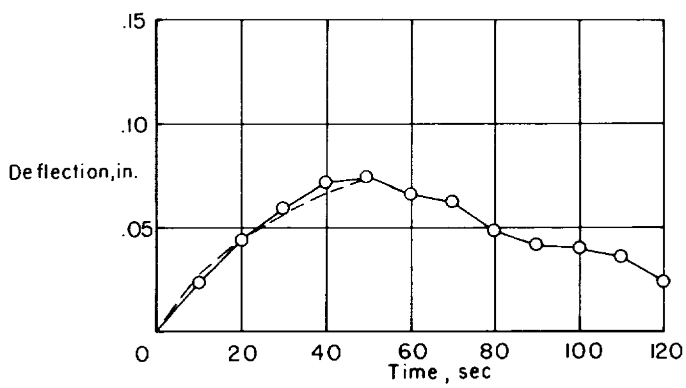


(b) Temperature history for panel D, test 5.

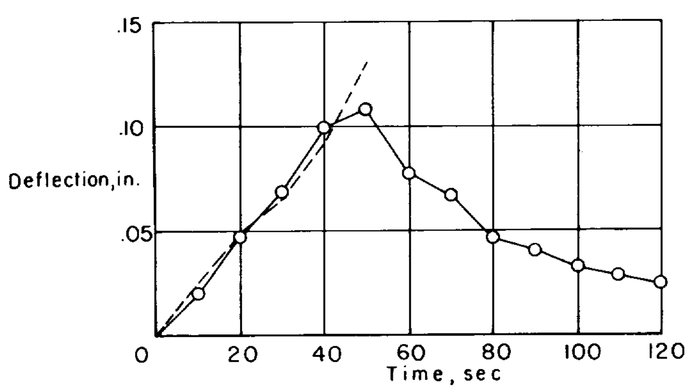
Figure 7.- Temperature histories for static radiant-heating tests 4 and 5.



(a) Deflection history for panel A, test 1.



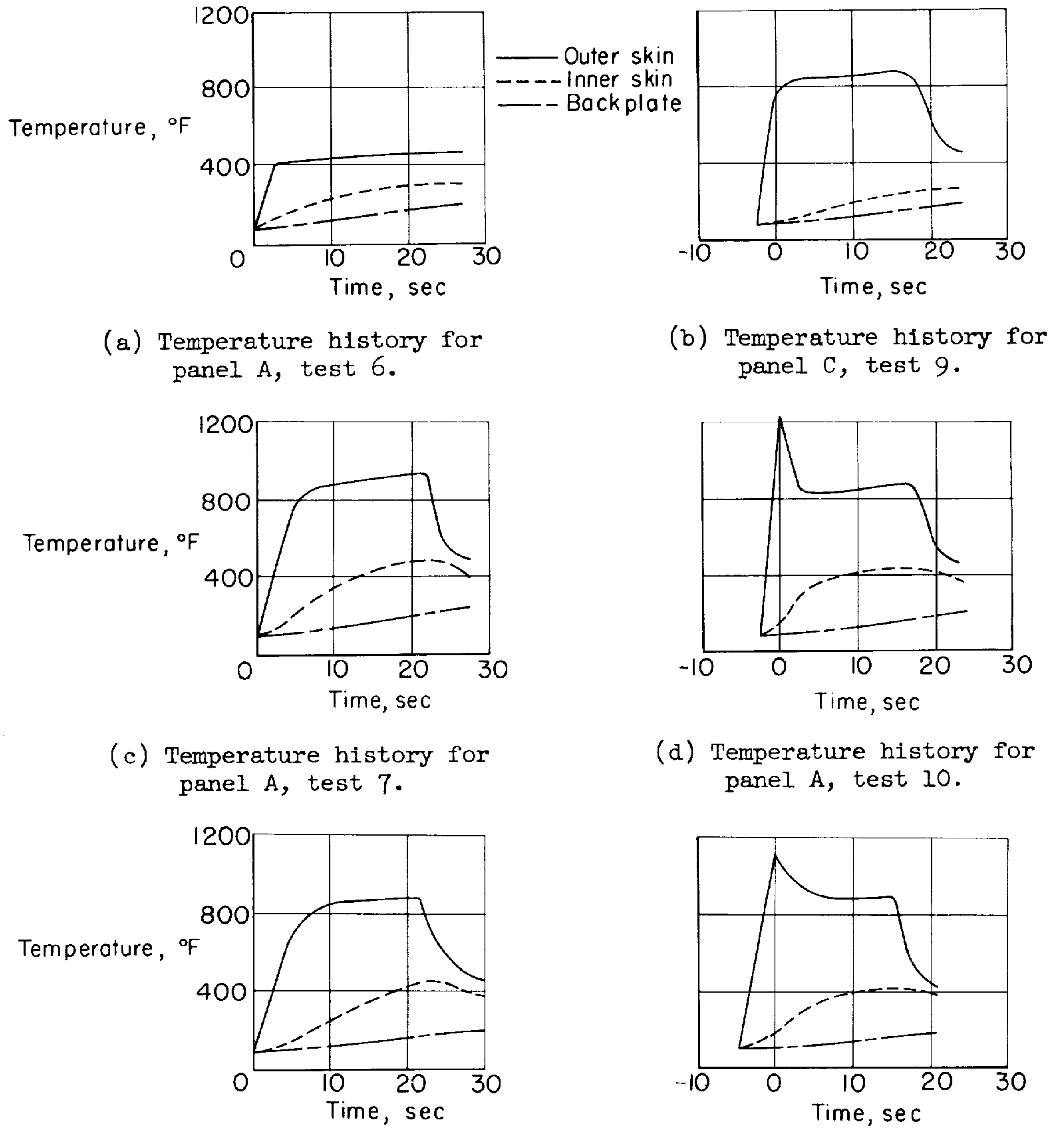
(b) Deflection history for panel B, test 2.



(c) Deflection history for panel C, test 3.

Figure 8.- Typical deflection histories for static radiant-heating tests.

[redacted]



(a) Temperature history for panel A, test 6.

(b) Temperature history for panel C, test 9.

(c) Temperature history for panel A, test 7.

(d) Temperature history for panel A, test 10.

(e) Temperature history for panel B, test 8.

(f) Temperature history for panel B, test 11.

Figure 9.- Typical temperature histories for wind-tunnel tests.

[redacted]

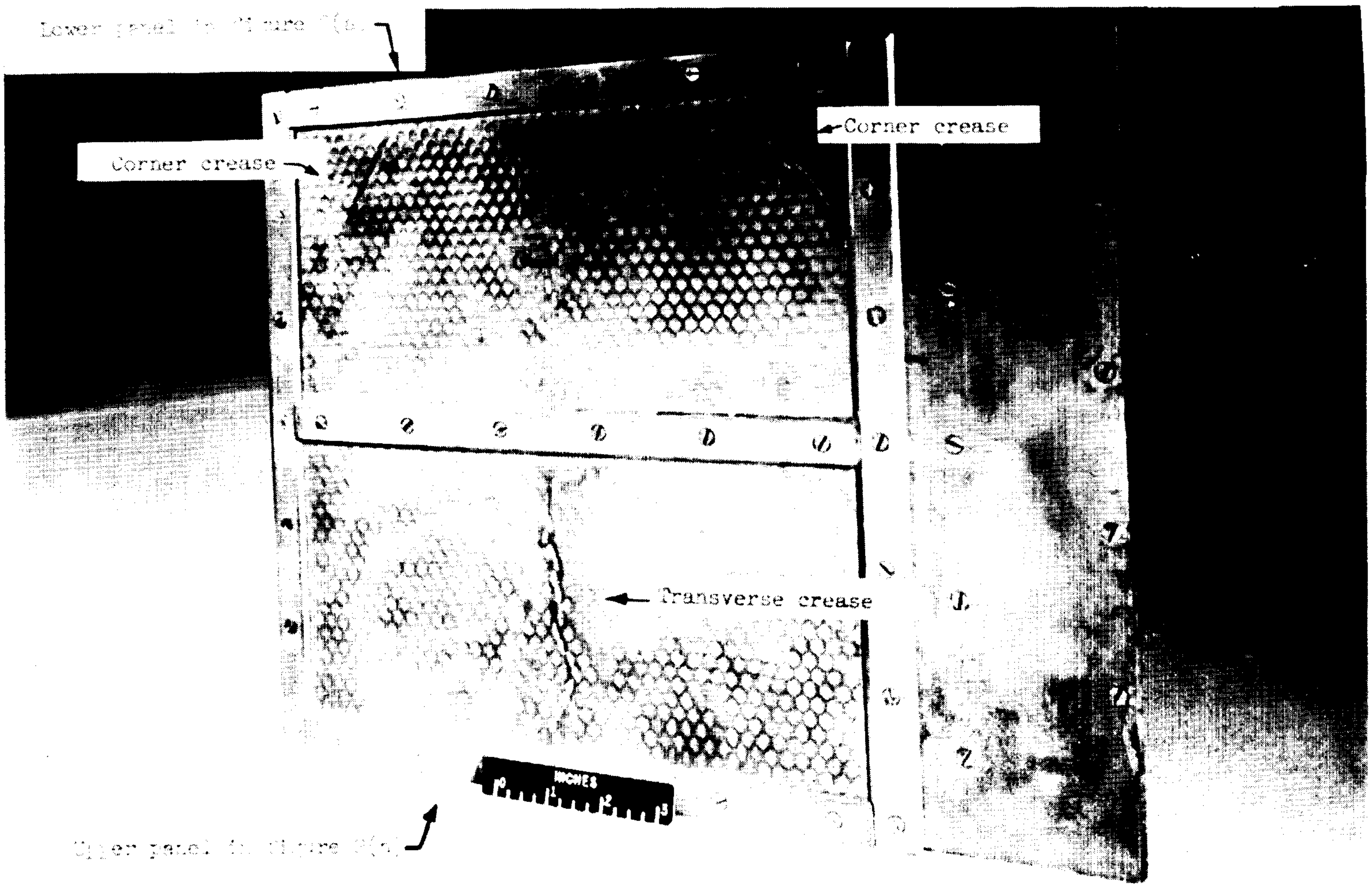


Figure 10.- Buckled panel (panel A after test 10). L-57-5607.1

[redacted]

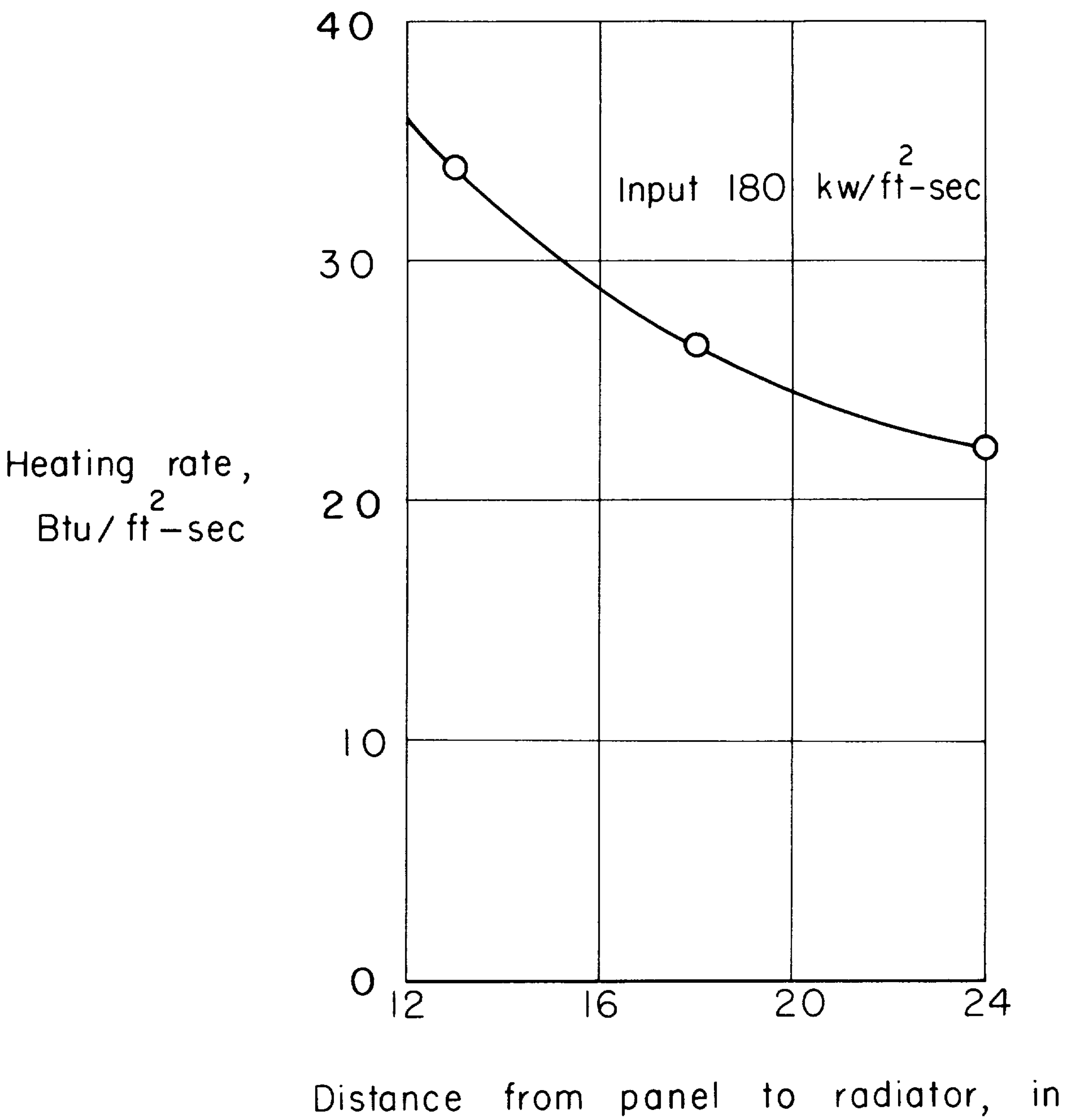


Figure 11.- Effect of distance from radiant heater on heating rates.

[redacted]